

**EVALUATION OF AMBIENT pH IN THE
MERRIMACK RIVER AT THE COOLING WATER INTAKE OF
MERRIMACK STATION**

TECHNICAL MEMORANDUM

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R-21351.000
R-22240.077

March 2009
Revised December 2020

Evaluation of Ambient pH in the Merrimack River at the Cooling Water Intake to Merrimack Station

Technical Memorandum

Introduction. The United States Environmental Protection Agency (EPA), in collaboration with the New Hampshire Department of Environmental Services (NHDES), New Hampshire Fish and Game Department (NHFG) and the United States Fish and Wildlife Service (USFWS) issued a Final NPDES Permit NH0001465 (“the Final NPDES Permit”) for Merrimack Station (“the Station”) effective on 1 October 2020. Part I.F.4 of the Station’s final NPDES Permit provides: “The pH range of 6.5 to 8.0 Standard Units (S.U.) must be achieved in the final effluent unless the Permittee can demonstrate to NHDES-WD: (1) that the range should be widened due to naturally occurring conditions in the receiving water or (2) that the naturally occurring receiving water pH is not significantly altered by the Permittee’s discharge. The scope of any demonstration project must receive prior approval from NHDES-WD. In no case, shall the above procedure result in pH limits outside the range of 6.0 - 9.0 S.U., which is the federal effluent limitation guidelines for pH commonly found in 40 CFR subchapter N Parts 405 through 471.”

The footnotes for Part I.A.1 through I.A.12 of the Final NPDES Permit, specifically footnote (12), describe how pH compliance is measured and reported as “This pH range limit shall not be exceeded at any time (instantaneous lower and upper range values). The Permittee shall report minimum and maximum values as well as the total number of exceedances in the field provided on each DMR. See Part I.F.4 for instructions allowing the Permittee to submit a demonstration that the pH range should be widened due to naturally occurring conditions.”

Historic measurement of pH at the Station’s intake (Monitoring Station N-5) has documented periodic exceedances of the pH requirements specified by the Station’s NPDES Permit. This Technical Memorandum examines the monitoring record available for the recent 17.5 year period of record from June 2002 through December 2019 and provides a demonstration that background pH conditions immediately upstream of the Station have periodically and repeatedly exceeded the specified NPDES Permit pH criteria. The pH data that exceed the allowable pH range specified in the Final NPDES Permit shall be referred to herein as out-of-permitted-range (“OOPR”).

Methods. The Station’s current NPDES permit requires continuous pH monitoring at Monitoring Station N-5, a water quality sampling station located at the Station Unit #2

cooling water intake structure (“CWIS”) approximately 2,200 feet upstream of the Station cooling water discharge, and therefore considered to represent the “upstream” or “ambient” pH in the Merrimack River water exposed to withdrawal at the Station. A 17.5-year period of record (June 2002 through December 2019) was obtained to evaluate Monitoring Station N-5 ambient pH data. The June through May evaluation period was selected because the Station reports pH and other monitoring data on a June through May annual timeframe. In this report we analyze the Station’s pH data reported to the nearest 10^{-3} unit, which we consider accurate to the nearest 0.1 pH unit.

Data retrieval methods varied somewhat, depending on the year. For the period June 2002 through May 2007, five annual monitoring reports were obtained from the Station showing the daily maximum, minimum, and average pH value for each day for Monitoring Station N-5. These 2002 through 2007 monitoring reports were prepared by the Station as part of its NPDES reporting requirements and represent the maximum, minimum and average daily pH values based on 96, 15-minute values collected for each day for that reporting year. These five years of monitoring reports were reviewed to identify those days when either the daily minimum reported pH value was below 6.5 S.U. or the daily maximum reported pH value was above 8.0. All blocks of data were retrieved from the Station as Excel files if they contained one or more of the daily maximum or minimum pH values that were below 6.5 S.U. or above 8.0 S.U. The pH monitoring data were stored by the Station on its system computer in nominal 14-day blocks, consisting of one pH record for each 15-minute interval at Monitoring Station N-5. The exact length of each retrieved data block varied; e.g. some blocks of retrieved data were longer than 14 days. For consistency, the blocks of retrieved data are referred to herein as “14-day blocks”. The 14-day blocks of 15-minute measurements for most of the study period were not retrieved or reviewed because the annual reports noted no daily maximum or minimum pH values outside of the pH range of 6.5 to 8.0 S.U. Consequently, it was assumed that all 15-minute data not retrieved within the 14-day data blocks were within the 6.5 to 8.0 S.U. pH criteria range specified in the Final NPDES Permit, and contributed to a total of 35,040 observations per year (35,136 observations in a leap year). For this evaluation, pH measurements were considered suspect when an individual record exhibited an instantaneous change in the absolute value of pH from the previous 15-minute measurement greater than 1.0 S.U., or for records located within a continuous segment of measurements bracketed by clearly erroneous values (e.g. negative recorded pH values). Regarding data quality, only 4% (2,468) of the 65,880 15-minute intervals represented by all 14-day blocks retrieved for June 2002 through May 2007 contained missing or suspect 15-minute data. This percentage (4%) of missing or suspect 15-minute data is also presumed representative of the 14-day blocks of data that were not retrieved for analysis, and thus considered within permitted range, as described above.

For the period June 2007 through May 2014, 15-minute data were obtained from the Station in a single continuous series of data as an Excel spreadsheet, not in 14-day data blocks as was available from June 2002 through May 2007, and all data were incorporated into our working database. Data quality for the June 2007 through May 2014 dataset was also excellent – only 4% (9,749/245,472 15-minute data records) of the 15-minute time events contained missing or suspect 15-minute data. As with the June 2002 through May 2007 data set, missing data were presumed to be within the Final NPDES Permit pH standards. This is a conservative assumption, because in some cases, missing data either preceded or followed OOPR data, so it is possible, perhaps probable, that some of the missing data are OOPR but unrecorded.

For the period June 2014 through December 2019, 15-minute data were obtained from the Station in a single continuous series of data as an Excel spreadsheet, and all data were incorporated into our working database. Data quality for the June 2014 through December 2019 dataset was excellent – only 1% (2,202/195,840) of the 15-minute time events contained missing or suspect 15-minute data. As with the June 2002 through May 2014 data sets, missing data were presumed within the Final NPDES Permit pH standards, the same conservative assumption as applied to the previous pH data sets.

Results and Discussion. A summary of monthly OOPR instantaneous (15-minute) pH values is presented in Table 1. In the 17.5 reporting years from June 2002 through December 2019, OOPR pH values were recorded in every year except during the single year from June 2012 through May 2013. The number of months per reporting year in which OOPR 15-minute pH values occurred ranged from zero to as many as eleven of the twelve months in the year. Considering only months with OOPR values, the number of OOPR instantaneous values per month ranged from as few as 1 (<0.1% of the time during May 2003, and March and April of 2016) to as many as 2,137 (74.2% of the time during April 2005). Table 1 also shows the total number of 15-minute (instantaneous) minimum and maximum pH observations for each month in which exceedances were recorded. During the entire 17.5-year period, the minimum and maximum pH values recorded were 5.81 S.U. during December 2004 and 8.48 S.U. during August 2002, respectively. The annual number of observed pH values less than 6.5 declined over the period 2002 through 2014, and increased during 2014 through 2016 (NHDES 2016), followed by a decreasing trend from 2016 through 2019. This may indicate a more neutral ambient pH in the Merrimack River upstream of Merrimack Station, or perhaps an increase in primary production, which increases pH during daylight hours (Hynes 1970). These observations are consistent with long-term (40+ years) pH monitoring conducted by NHDES which has found significant increases in pH in precipitation in Concord (NHDES 2015), which could expand the upper pH range of ambient Merrimack River conditions due to naturally occurring conditions.

A monthly summary of instantaneous (recorded at 15-minute intervals) measurements, averaged over the 17.5-year study period, is presented in Table 2. During this June 2002 through December 2019 period, each month had some instantaneous values of OOPR pH recorded. Monthly average number of instantaneous measurements of OOPR pH varied from June with the lowest average of only 21 instantaneous records or 0.7% of the measurements, to April, with the highest average number of OOPR instantaneous measurements at 383 instantaneous values or 13.3% of all April instantaneous records.

An annual summary of instantaneous (recorded at 15-minute intervals) readings is presented in Table 3. Here, it can be seen that the fewest number of OOPR instantaneous pH measurements was 0 (0% of the time) in the June 2012 through May 2013 reporting period, while the most was 4,467 (12.8% of the time) during reporting year of June 2006 through May 2007. Based on the 17.5-year study period, an average of 1,739 instantaneous (15-minute interval) measurements per year were OOPR with respect to the pH criteria. Thus, ambient pH in the Merrimack River upstream of Merrimack Stream was OOPR for approximately 5.0% of the time from June 2002 through December 2019. The frequency distribution of valid 15-minute observations for the entire period of June 2002 through December 2019 is shown in Figure 1. Figure 1 illustrates that most OOPR pH records (annual average of 1,739 or greater than 99% of the total OOPR instantaneous pH observations) were caused by low rather than high pH. Even so, there were several times during August and September of 2002 when pH levels at Monitoring Station N-5 at the Station cooling water intake exceeded 8.0 S.U. A distinct diel trend was observed in the data during certain periods in both months where pH peaked above 8.0 in the late afternoon – early evening, fell to minima in the early post-dawn hours, and then rose again in the daylight hours to another late afternoon – early evening maxima.

The diel cycling of pH maximum and minimum values suggests a biological influence, probably by the daily cycle of periphyton (attached algae) primary production, which are typically found in free-flowing rivers and streams and may achieve high rates of carbon fixation around solar noon (Hynes 1970). Because the June 2002 through May 2003 reporting period was a relatively low flow year, particularly during the late summer-early fall, it is possible that algal influence on pH was heightened due to the prevailing low flow conditions. It should also be noted that occurrences of OOPR pH are generally associated with episodic events of some duration as opposed to random, instantaneous occurrences. This is because low pH events in rivers and streams are generally associated with low pH rainfall/snowmelt runoff events during high flows while high pH events, such as occurred in August and September of 2002, seem to be associated with diel cycling of periphyton photosynthetic activity during low flows.

Close examination of the 15-minute data indicates that both types of OOPR pH occur for periods of consecutive hours to days, reflective of diel or seasonal cycles.

Conclusions. Analysis of 17.5 years of instantaneous (15-minute) ambient pH data from Merrimack Station revealed that the pH permit range of 6.5 to 8.0 S.U. specified in the Final NPDES Permit does not encompass the natural range of variability observed in the ambient Merrimack River waters at the Station. This observation leads to a recommendation that the pH criteria in the Station's Final NPDES Permit be expanded from 6.5-8.0 to 6.0-8.5 S.U. to encompass the observed "naturally occurring" range of pH values in the Merrimack River at the Station's intake during this historical data period. However, it may be pragmatic to buffer this range to account for potential future natural variability not observed in the 17.5-year historical data period analyzed for this evaluation, to accommodate pH values greater than 8.5 S.U. The proposed, expanded pH range is consistent with the recommendations specified in the Part I.F.4 of the Final NPDES Permit. This recommendation is supported by the following results:

- Instantaneous (15-minute) pH values observed during June 2002 through December 2019 ranged from a minimum of 5.81 S.U. to a maximum of 8.48 S.U. No pH values less than 6.0 S.U. were observed for the January 2005 through December 2019 reporting period. This may be a reflection of continuing reductions in acid precipitation as documented by NHDES (2015) which may also decrease the likelihood that pH values less than 6.0 S.U. would occur in the future. Nevertheless, numerous occurrences of pH less than 6.5 S.U. were observed in nearly all years examined, so while pH conditions may be improving, periodic low pH events are likely to continue.
- Exceedances of the current 8.0 S.U. requirement are also present in this data set and the risk of episodic pH values above this threshold remains, especially under conditions of low flow, high nutrient concentrations, and high temperature, as might occur during late summer.
- Ambient instantaneous (15-minute) pH values in the Merrimack River observed at the Merrimack Station intake were OOPR for an average of 5.0% of the 15-minute measurements during the 17.5-year reporting period from June 2002 through December 2019, and as much as 12.8% of the time during the June 2006 through May 2007 reporting period. These OOPR pH observations are due to ambient conditions beyond the control of the Station is expected to continue to be observed for the Final NPDES Permit period.

The Station's Final NPDES Permit contains specific language that allows the pH compliance range to be modified by consulting NHDES-WD as quoted in the first

paragraph of this Technical Memorandum. This Technical Memorandum clearly demonstrates that the Station's pH compliance range should be expanded from 6.5-8.0 S.U. to 6.0-8.5 S.U., or greater than 8.5 S.U., and is submitted to GSP Merrimack, LLC in support of an expanded instantaneous pH compliance range based on an empirical analysis of historic (June 2002 through December 2019) Merrimack River upstream (Intake, Station N5) instantaneous (15-minute) pH data as specified by Part I.F.4 of the Final NPDES Permit for Merrimack Station.

References.

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Table 1. Number of Instantaneous (recorded every 15-minutes) Measurements of Out-of-Permitted-Range ("OOPR") pH per Month Observed at Monitoring Station N-5, Merrimack Station Unit #2 Intake, Merrimack River, June 2002-December 2019 (min/max = lowest/highest measured pH value).					
Reporting Year	Month (total number of 15-minute events)	pH<6.5	pH>8.0	Total OOPR Events	% OOPR Events
2002/2003	June (2,880)	0	0	0	0
	July (2,976)	0	0	0	0
	August (2,976)	77 (min = 6.02)	89 (max = 8.48)	166	5.6
	September (2,880)	238 (min = 6.00)	111 (max = 8.42)	349	12.1
	October (2,976)	0	0	0	0
	November (2,880)	0	0	0	0
	December (2,976)	0	0	0	0
	January (2,976)	0	0	0	0
	February (2,688)	0	0	0	0
	March (2,976)	687 (min = 6.15)	0	687	23.1
	April (2,880)	1,248 (min = 6.05)	0	1,248	43.3
	May (2,976)	1 (min = 6.48)	0	1	<0.1
2003/2004	June (2,880)	0	0	0	0
	July (2,976)	0	0	0	0
	August (2,976)	149 (min = 6.32)	0	149	5.0
	September (2,880)	0	0	0	0
	October (2,976)	32 (min = 6.47)	0	32	1.1
	November (2,880)	163 (min = 6.41)	0	163	5.7
	December (2,976)	712 (min = 6.37)	0	712	23.9
	January (2,976)	532 (min = 6.29)	0	532	17.9
	February (2,784)	0	0	0	0
	March (2,976)	11 (min = 6.44)	0	11	0.4
	April (2,880)	474 (min = 6.19)	0	474	16.5
	May (2,976)	0	0	0	0
2004/2005	June (2,880)	0	0	0	0
	July (2,976)	0	0	0	0
	August (2,976)	0	0	0	0
	September (2,880)	0	0	0	0
	October (2,976)	0	0	0	0
	November (2,880)	45 (min. 6.40)	0	45	1.6
	December (2,976)	1,362 (min. 5.81)	0	1,362	45.8
	January (2,976)	6 (min = 6.48)	0	6	0.2
	February (2,688)	0	0	0	
	March (2,976)	13 (min = 6.45)	0	13	0.4
	April (2,880)	2,137 (min = 6.09)	0	2,137	74.2
	May (2,976)	352 (min = 6.42)	0	352	11.8

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Reporting Year	Month (total number of 15-minute events)	pH<6.5	pH>8.0	Total OOPR Events	% OOPR Events
2005/2006	June (2,880)	52 (min = 6.26)	0	52	1.8
	July (2,976)	0	0	0	0
	August (2,976)	0	0	0	0
	September (2,880)	262 (min = 6.39)	0	262	9.1
	October (2,976)	892 (min = 6.25)	0	892	30.0
	November (2,880)	204 (min = 6.42)	0	204	7.1
	December (2,976)	205 (min = 6.26)	0	205	6.9
	January (2,976)	129 (min = 6.45)	0	129	4.3
	February (2,688)	0	0	0	0
	March (2,976)	0	0	0	0
	April (2,880)	0	0	0	0
	May (2,976)	660 (min = 6.10)	0	660	22.2
2006/2007	June (2,880)	224 (min = 6.43)	0	224	7.8
	July (2,976)	0	0	0	0
	August (2,976)	0	0	0	0
	September (2,880)	0	0	0	0
	October (2,976)	1,094 (min = 6.09)	0	1,094	36.8
	November (2,880)	1,021 (min = 6.00)	0	1,021	34.5
	December (2,976)	0	0	0	0
	January (2,976)	1,806 (min = 6.05)	0	1,806	60.7
	February (2,688)	78 (min = 6.12)	0	78	2.9
	March (2,976)	225 (min = 6.27)	0	225	7.6
	April (2,880)	17 (min = 6.48)	0	17	0.6
	May (2,976)	2 (min = 6.48)	0	2	0.1
2007/2008	June (2,880)	4 (min = 6.49)	0	4	0.1
	July (2,976)	213 (min = 6.33)	0	213	7.2
	August (2,976)	0	0	0	0
	September (2,880)	0	0	0	0
	October (2,976)	92 (min = 6.39)	0	92	3.1
	November (2,880)	0	0	0	0
	December (2,976)	318 (min = 6.11)	0	318	10.7
	January (2,976)	0	0	0	0
	February (2,784)	160 (min = 6.05)	0	160	5.7
	March (2,976)	123 (min = 6.31)	0	123	4.1
	April (2,880)	215 (min = 6.27)	0	215	7.5
	May (2,976)	206 (min = 6.30)	0	206	6.9

Table 1. Number of Instantaneous (recorded every 15-minutes) Measurements of Out-of-Permitted-Range (“OOPR”) pH per Month Observed at Monitoring Station N-5, Merrimack Station Unit #2 Intake, Merrimack River, June 2002-December 2019 (min/max = lowest/highest measured pH value) (cont.)					
Reporting Year	Month (total number of 15-minute events)	pH<6.5	pH>8.0	Total OOPR Events	% OOPR Events
2008/2009	June (2,880)	2 (min = 6.49)	0	2	0.1
	July (2,976)	0	0	0	0
	August (2,976)	0	0	0	0
	November (2,880)	0	0	0	0
	December (2,976)	0	0	0	0
	January (2,976)	0	0	0	0
	February (2,688)	0	0	0	0
	March (2,976)	0	0	0	0
	April (2,880)	497 (min = 6.42)	0	497	17.3
	May (2,976)	0	0	0	0
2009/2010	June (2,880)	0	0	0	0
	July (2,976)	0	0	0	0
	August (2,976)	0	0	0	0
	September (2,880)	0	0	0	0
	October (2,976)	20 (min = 6.48)	0	20	0.7
	November (2,880)	0	0	0	0
	December (2,976)	0	0	0	0
	January (2,976)	0	0	0	0
	February (2,688)	0	0	0	0
	March (2,976)	68 (min = 6.47)	0	68	2.3
	April (2,880)	361 (min = 6.43)	0	361	12.5
	May (2,976)	0	0	0	0
2010/2011	June (2,880)	0	0	0	0
	July (2,976)	0	0	0	0
	August (2,976)	0	0	0	0
	September (2,880)	0	0	0	0
	October (2,976)	0	0	0	0
	November (2,880)	0	0	0	0
	December (2,976)	813 (min = 6.17)	0	813	27.3
	January (2,976)	0	0	0	0
	February (2,688)	0	0	0	0
	March (2,976)	165 (min = 6.34)	0	165	5.5
	April (2,880)	0	0	0	0
	May (2,976)	0	0	0	0

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Reporting Year	Month (total number of 15-minute events)	pH<6.5	pH>8.0	Total OOPR Events	% OOPR Events
2011/2012	June (2,880)	0	0	0	0
	July (2,976)	0	0	0	0
	August (2,976)	0	0	0	0
	September (2,880)	0	0	0	0
	October (2,976)	0	0	0	0
	November (2,880)	0	0	0	0
	December (2,976)	0	0	0	0
	January (2,976)	0	0	0	0
	February (2,784)	227 (min = 6.45)	0	227	8.2
	March (2,976)	0	0	0	0
	April (2,880)	0	0	0	0
	May (2,976)	0	0	0	0
2012/2013	June (2,880)	0	0	0	0
	July (2,976)	0	0	0	0
	August (2,976)	0	0	0	0
	September (2,880)	0	0	0	0
	October (2,976)	0	0	0	0
	November (2,880)	0	0	0	0
	December (2,976)	0	0	0	0
	January (2,976)	0	0	0	0
	February (2,688)	0	0	0	0
	March (2,976)	0	0	0	0
	April (2,880)	0	0	0	0
	May (2,976)	0	0	0	0
2013/2014	June (2,880)	0	0	0	0
	July (2,976)	57 (min = 6.48)	0	57	1.9
	August (2,976)	0	0	0	0
	September (2,880)	0	0	0	0
	October (2,976)	267 (min = 6.35)	0	267	9.0
	November (2,880)	13 (min = 6.45)	0	13	0.5
	December (2,976)	0	0	0	0
	January (2,976)	0	0	0	0
	February (2,688)	0	0	0	0
	March (2,976)	0	0	0	0
	April (2,880)	3 (min = 6.49)	0	3	0.1
	May (2,976)	0	0	0	0

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Reporting Year	Month (total number of 15-minute events)	pH<6.5	pH>8.0	Total OOPR Events	% OOPR Events
2014/2015	June (2,880)	97 (min=6.42)	0	97	3.4
	July (2,976)	0	0	0	0
	August (2,976)	33 (min=6.42)	0	33	1.1
	September (2,880)	0	0	0	0
	October (2,976)	21 (min=6.45)	0	21	0.7
	November (2,880)	0	0	0	0
	December (2,976)	1,401 (min=6.14)	0	1,401	47.1
	January (2,976)	1,624 (min=6.09)	0	1,624	54.6
	February (2,688)	0	0	0	0
	March (2,976)	0	0	0	0
	April (2,880)	2 (min=6.50)	0	2	<0.1
	May (2,976)	0	0	0	0
2015/2016	June (2,880)	0	0	0	0
	July (2,976)	393 (min=6.44)	0	393	13.2
	August (2,976)	0	0	0	0
	September (2,880)	0	0	0	0
	October (2,976)	434 (min=6.38)	0	434	14.6
	November (2,880)	0	0	0	0
	December (2,976)	0	0	0	0
	January (2,976)	0	0	0	0
	February (2,784)	282 (min=6.42)	0	282	10.1
	March (2,976)	1 (min=6.49)	0	1	<0.1
	April (2,880)	1 (min=6.49)	0	1	<0.1
	May (2,976)	23 (min=6.41)	0	23	0.8
2016/2017	June (2,880)	0	0	0	0
	July (2,976)	0	0	0	0
	August (2,976)	43 (min=6.37)	0	43	1.4
	September (2,880)	0	0	0	0
	October (2,976)	572 (min=6.32)	0	572	19.2
	November (2,880)	0	0	0	0
	December (2,976)	182 (min=6.39)	0	182	6.1
	January (2,976)	212 (min=6.34)	0	212	7.1
	February (2,688)	0	0	0	0
	March (2,976)	1,821 (min=6.29)	0	1,821	61.2
	April (2,880)	1,563 (min=6.24)	0	1,563	54.3
	May (2,976)	0	0	0	0

Table 1. Number of Instantaneous (recorded every 15-minutes) Measurements of Out-of-Permitted-Range (“OOPR”) pH per Month Observed at Monitoring Station N-5, Merrimack Station Unit #2 Intake, Merrimack River, June 2002-December 2019 (min/max = lowest/highest measured pH value) (cont.)					
Reporting Year	Month (total number of 15-minute events)	pH<6.5	pH>8.0	Total OOPR Events	% OOPR Events
2017/2018	June (2,880)	0	0	0	0
	July (2,976)	291 (min=6.33)	0	291	9.8
	August (2,976)	0	0	0	0
	September (2,880)	0	0	0	0
	October (2,976)	59 (min=6.45)	0	59	2
	November (2,880)	0	0	0	0
	December (2,976)	608 (min=6.43)	0	608	20.4
	January (2,976)	269 (min=6.42)	0	269	9
	February (2,688)	0	0	0	0
	March (2,976)	0	0	0	0
	April (2,880)	0	0	0	0
	May (2,976)	30 (min=6.15)	0	30	1
2018/2019	June (2,880)	0	0	0	0
	July (2,976)	37 (min=6.48)	0	37	1.2
	August (2,976)	0	0	0	0
	September (2,880)	0	0	0	0
	October (2,976)	0	0	0	0
	November (2,880)	40 (min=6.40)	0	40	1.4
	December (2,976)	0	0	0	0
	January (2,976)	0	0	0	0
	February (2,688)	23 (min=6.18)	0	23	0.9
	March (2,976)	96 (min=6.15)	0	96	3.2
	April (2,880)	0	0	0	0
	May (2,976)	1,082 (min=6.37)	0	1,082	36.4
2019/2020	June (2,880)	0	0	0	0
	July (2,976)	3 (min=6.48)	0	3	0.1
	August (2,976)	0	0	0	0
	September (2,880)	0	0	0	0
	October (2,976)	0	0	0	0
	November (2,880)	38 (min=6.48)	0	38	1.3
	December (2,976)	51 (min=6.45)	0	51	1.7

**Table 2. Average Number of Instantaneous (recorded every 15-minutes)
Measurements of Out-of-Permitted-Range (“OOPR”) pH per Month
Observed at Monitoring Station N-5, Merrimack Station Unit #2 Intake,
Merrimack River, June 2002-December 2019.**

Month (average number of 15-minute events)	pH<6.5	pH>8.0	Total OOPR Events	% OOPR Events
January (2,976)	269	0	269	9.0
February (2,711)	45	0	45	1.7
March (2,976)	189	0	189	6.4
April (2,880)	383	0	383	13.3
May (2,976)	139	0	139	4.7
June (2,880)	21	0	21	0.7
July (2,976)	55	0	55	1.8
August (2,976)	17	5	22	0.7
September (2,880)	28	6	34	1.2
October (2,976)	194	0	194	6.5
November (2,880)	85	0	85	3.0
December (2,976)	314	0	314	10.6
Annual Average (35,063)^a	1,739	11	1,750	5.0

- a. Sum of monthly average number of 15-minute events and instantaneous OOPR measurements across the 17.5-year monitoring period.

Table 3. Number of Instantaneous (recorded every 15-minutes) Measurements of Out-of-Permitted-Range (“OOPR”) pH per Reporting Year Observed at Monitoring Station N-5, Merrimack Station Unit #2 Intake, Merrimack River, June 2002-December 2019.

Year (total number of 15-minute events)	pH<6.5	pH>8.0	Total OOPR Events	% OOPR Events
2002/2003 (35,040)	2,251	200	2,451	7.0
2003/2004 (35,136)	2,073	0	2,073	5.9
2004/2005 (35,040)	3,915	0	3,915	11.2
2005/2006 (35,040)	2,404	0	2,404	6.9
2006/2007 (35,040)	4,467	0	4,467	12.8
2007/2008 (35,136)	1,331	0	1,331	3.9
2008/2009 (35,040)	499	0	499	1.4
2009/2010 (35,040)	449	0	449	1.3
2010/2011 (35,040)	978	0	978	2.8
2011/2012 (35,136)	227	0	227	0.6
2012/2013 (35,040)	0	0	0	0
2013/2014 (35,040)	340	0	340	1.0
2014/2015 (35,040)	3,178	0	3,178	9.1
2015/2016 (35,136)	1,134	0	1,134	3.2
2016/2017 (35,040)	4,393	0	4,393	12.5
2017/2018 (35,040)	1,257	0	1,257	3.6
2018/2019 (35,040)	1,278	0	1,278	3.6
2019/2020 (20,544)	92	0	92	0.4

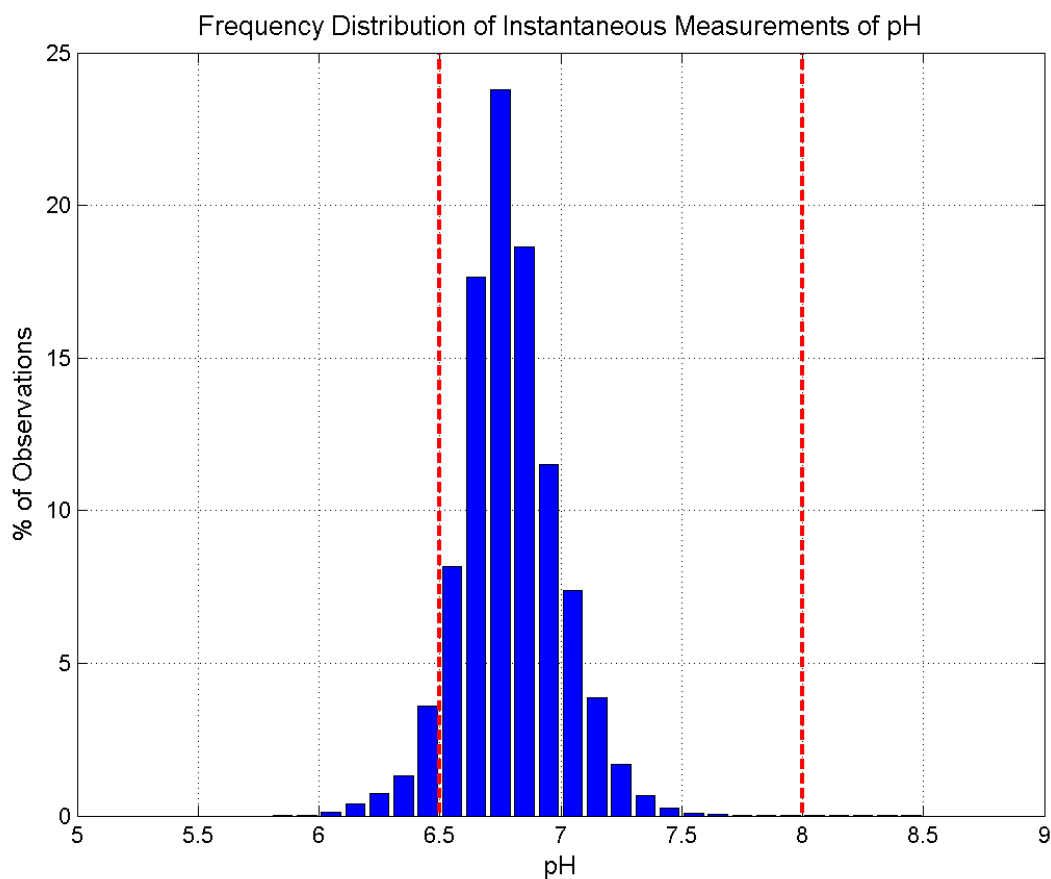


Figure 1. Frequency distribution of 15-minute (“instantaneous”) pH observations (n=492,660) at monitoring station N-5, Merrimack Station unit #2 intake, Merrimack River, June 2002 through December 2019. The red dashed lines indicate the permitted pH range of the Final NPDES Permit.